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THE EFFECT OF SILICON, TIN AND CHROMIUM ON THE CORROSION AND MECHANICAL PROPERTIES OF ZIRCONIUM - MOLYBDENUM - NIOBIUM ALLOYS

by

N.M. Gruzdeva, A.S. Adamova

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О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
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*<u>ye</u> initially, after vowels, and after ъ, ь; <u>e</u> elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

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THE EFFECT OF SILICON, TIN AND CHROMIUM ON THE CORROSION AND MECHANICAL PROPERTIES OF ZIRCONIUM - MOLYBDENUM - NIOBIUM ALLOYS.

N. M. Gruzdeva, A. S. Adamova.

According to the data of the study of the corrosion properties of alloys of the ternary system of zirconium - niobium - molybdenum, the compositions were determined of the two most corrosion-resistant alloys Zr+0.80% Nb+0.20% Mo and Zr+50% Nb+50% Mo [1].

FOOTNOTE [1]. See the article by N. M. Gruzdeva, A. S. Adamova in this collection, pg. 204. *ENDFOOTNOTE*.

This investigation had as its goal the explanation of the effect of tin, chromium and silicon on the corrosion and mechanical properties of the indicated ternary alloys, and also on the alloy of zirconium with 0.50% Nb+0.20% Mo. Tin and chromium were selected as the alloying additives, since their favorable effect on the corrosion and strength properties of zirconium [1] is well known. The selection of silicon was based on the fact that its addition to 1.75% titanium strongly increases the heat resistance of titanium at 800 and 1000° [2]. The alloying additions of tin, chromium and silicon were introduced to the ternary alloys in small quantities: 0.20-0.30% Sn, 0.10% Cr or Si.

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Five groups of alloys were studied: Group I - ternary alloy Zr+0.80% Nb+0.20% Mo and quaternary based on it with additions of tin, chromium or silicon; II - ternary alloy Zr+0.50% Nb+0.20% Mo and quaternary based on it with additions of tin, chromium or silicon; III - quaternary alloy Zr+0.50% NB+0.20% Mo+0.20% Sn and quintuple based on it with additions of chromium or silicon; IV - ternary alloy Zr+0.50% Nb+0.50% Mo and quaternary based on it with additions of tin, chromium or silicon; V - quaternary alloy Zr+0.50% Nb+0.50% Mo+0.20% Sn and quintuple based on it with additions of chromium or silicon.

Serving as the initial materials for manufacturing the alloys were iodide zirconium with a purity of 99.7%, molybdenum wire with a purity of 99.68%, sintered niobium with a purity of 99.3%, hydride chromium with a purity of 99.9%, tin and silicon of the Kahlbaum brand. The alloys were melted in an arc furnace in an atmosphere of pure argon. Iodide zirconium was used as the getter. The alloys were remelted 6-8 times with the necessary inversion of the alloys before each melting. A chemical analysis of the alloys as to the content of molybdenum, chromium and silicon showed a good coincidence with the stock composition; therefore, from here on, the composition of the alloys is given according to charge. The poured alloys proceeded from forging to drilling at a temperature of 1000-1100°. The alloys of all compositions were forged well, without cracks. Part of the forged alloys was tempered for 20 min. at 650°. From the forged and tempered alloys, samples were bored out for conducting mechanical tests, along

with cylindrical samples for corrosion tests. Furthermore, from the poured alloys, cylindrical samples were also bored out for corrosion tests. Microstructural investigation of the poured alloys showed that unalloyed zirconium and all alloys not containing silicon, had a coarse-grained martensitic structure, alloys with silicon were characterized by a fine-grained structure and contained precipitations of the second phase, apparently, Zr_4Si, since the solubility of silicon in zirconium is extremely small (~0.2 wt.% at 1610°) [3].

Oxidation of the alloys in air was conducted at 650° for 20 hours. The samples were placed into quartz cups which were preliminarily finished to a fixed weight, they were weighed and maintained for 20 hours in an open shaft furnace, after which, the cups with the alloys were cooled in a desiccator. The data obtained are cited in Table 1. The results of testing show that all alloys without exception are oxidized much stronger than unalloyed zirconium. Furthermore, the introduction of chromium, silicon and especially tin leads to deterioration in the heat resistance of the ternary alloys of zirconium with niobium and molybdenum. The most heat resistant proved to be alloys of Zr+0.80% Nb+0.20% Mo and Zr+0.80% Nb+0.20 Mo+0.10% Cr, but they are also oxidized approximately 30 times more strongly than zirconium.

Testing of the corrosion resistance of alloys in water was conducted in a special autoclave at temperatures of 350 and 400° and a pressure of 168 and 250 atm. respectively. Alloys in the poured,

forged and tempered states were subjected to testing. The poured and forged alloys were tested for 3890 hours, weighing of the samples was conducted 265, 515, 875, 1355, 2620 and 3890 hours after the beginning of the tests. The forged and then tempered alloys were tested for 1500 hours, weighing was conducted every 500 hours. The results of testing of the poured alloys are presented in Table 2, where the values of increase in weight for 1 m^2 and the rate of corrosion for a finite testing time are given.

It follows from Table 2 that the initial zirconium was removed from the tests after 1355 hours, since it began to strongly decrease in weight.

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Table 1.

Heat resistance of alloys in air at 650°.

(a) Номер сплава	(b) Содержание легирующих элементов, вес. %					(c) Привес за 20 час., г/м²	(d) Скорость коррозии за 20 час., г/м²
	Nb	Mo	Sn	Cr	Si		
Zr						3,09	0,154
1	0,80	0,20	0,20	—	—	246,2	12,31
2	0,80	0,20	—	0,10	—	88,72	4,43
3	0,80	0,20	—	—	—	91,71	4,58
4	0,80	0,20	—	—	0,10	181,9	9,09
5	0,50	0,20	0,30	—	—	226,1	11,31
6	0,50	0,20	—	0,10	—	142,9	7,14
7	0,50	0,20	—	—	—	150,5	7,52
8	0,50	0,20	—	—	0,10	231,2	11,61
9	0,50	0,20	0,20	—	0,10	288,0	14,4
10	0,50	0,20	0,20	—	—	276,7	13,83
11	0,50	0,20	0,20	0,10	—	256,4	12,82
12	0,50	0,50	0,20	—	—	246,5	12,32
13	0,50	0,50	—	0,10	—	171,4	8,57
14	0,50	0,50	—	—	—	157,2	7,86
15	0,50	0,50	—	—	0,10	146,3	7,31
16	0,50	0,50	0,20	—	0,10	467,2	23,36
17	0,50	0,50	0,30	—	—	383,1	19,16
18	0,50	0,50	0,20	0,10	—	348,3	21,93

Key: (a). Alloy number. (b). Content of alloying elements, wt.%. (c). Increase in weight for 20 hours, g/m². (d). Rate of corrosion for 20 hours, g/m².

Table 2.

Corrosion resistance of poured alloys in water at 350° and testing for 3890 hours.

(a) Номер сплава	(b) Содержание легирующих элементов (по шихте), вес. %					(c) Привес за это время, г/м²	(d) Скорость коррозии за это время, г/м²·час
	Nb	Mo	Sn	Cr	Si		
Zr [1]						—528,0	—0,3900
1	0,80	0,20	0,20	—	—	10,65	0,0027
2	0,80	0,20	—	0,10	—	5,56	0,0014
3	0,80	0,20	—	—	—	3,90	0,0010
4	0,80	0,20	—	—	0,10	6,07	0,0015
5	0,50	0,20	0,30	—	—	5,62	0,0014
6	0,50	0,20	—	0,10	—	3,87	0,0010
7	0,50	0,20	—	—	—	4,83	0,0012
8	0,50	0,20	—	—	0,10	8,32	0,0021
9	0,50	0,20	0,20	—	0,10	7,87	0,0020
10	0,50	0,20	0,20	—	—	6,97	0,0018
11	0,50	0,20	0,20	0,10	—	3,60	0,0009
12	0,50	0,50	0,20	—	—	9,43	0,0024
13	0,50	0,50	—	0,10	—	5,69	0,0014
14	0,50	0,50	—	—	—	4,92	0,0012
15	0,50	0,50	—	—	0,10	9,97	0,0025
16	0,50	0,50	0,20	—	0,10	10,68	0,0027
17	0,50	0,50	0,30	—	—	5,83	0,0015
18	0,50	0,50	0,20	0,10	—	7,29	0,0019

Key: (a). Alloy number. (b). Content of the alloying elements (according to charge), wt.%. (c). Increase in weight during this time, g/m². (d). Rate of corrosion during this time, g/m²·h.

FOOTNOTE [1]. Time of testing - 1355 hours. ENDFOOTNOTE.

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The zirconium was already covered with a white scaled shell of corrosion products after the first 265 hours of being maintained in the autoclave. The most corrosion-resistant, the rate of corrosion of which did not exceed 0.0010 g/m²·h for 3890 hours, proved to be alloys

3 (0.80% Nb+0.20% Mo), 6 (0.50% Nb+0.20% Mo+0.10% Cr) and 11 (0.50% Nb+0.20% Mo+0.20% Sn+0.10% Cr). All alloys without exception, after 3890 hours of testing, were covered with a shiny dense bluish-black/ferrous oxide film. In group I of the alloys based on a ternary alloy with 0.80% Nb+0.20% Mo, the additions of tin, chromium and silicon, impair the corrosion resistance of the initial alloy. In groups II and III (initial ternary with 0.50% Nb+0.20% Mo) and in groups IV and V of the alloys (initial ternary with 0.50% Nb+0.50% Mo), the addition of chromium increases the corrosion resistance of the alloys, while the addition of tin and silicon reduce it.

Table 3 gives the results of the corrosion tests of the forged alloys, the value of the increase in weight for 1 m^2 and the rates of corrosion are given for the latter holding time in the autoclave.

Unalloyed zirconium was removed from the tests after 265 hours, since even with this brief holding time in the autoclave it revealed a significant decrease in weight. The minimum speed of corrosion (0.0007-0.0010 $g/m^2 \cdot h$) for 3890 hours wss observed in the alloys, alloyed with chromium, these are alloys 11 (0.50% Nb+0.20% Mo+0.20% Sn+0.10% Cr) and 13 (0.50% Nb+0.50% Mo+0.10% Cr).

The forged and then tempered alloys were tested for corrosion in water at 350° and 168 atm. for 1500 hour. The data obtained are represented in Table 4, from which it is evident that included in the least stable are the alloys of all groups with silicon and alloys

based on ternary Zr+0.50% Nb+0.50% Mo. As a rule, the introduction of additions of chromium to alloys leads to a decrease in the rate of corrosion.

The samples of poured and forged alloys, after testing in water at 350° and 168 atm for 3890 hours, were tested in water at 400° and 250 atm for 1870 hours. Weighing of the samples was conducted after 500, 1000 and 1870 hours from the beginning of the tests. The obtained results are given in Tables 5 and 6. The values of the increase in weight for 1 m^2 and the rate of corrosion are only given for a finite time of holding in the autoclave.

Table 3.

Corrosion resistance of forged alloys in water at 350° and testing for 3890 hour.

(a) Номер сплава	(b) Содержание легирующих элементов (по шихте), вес. %					(c) Привес за это время, $г/м^2$	(d) Скорость коррозии за это время, $г/м^2 \cdot час$
	Nb	Mo	Sn	Cr	Si		
Zr [1]	—	—	—	—	—	−92,17	−0,3478
4	0,80	0,20	—	—	0,10	5,33	0,0014
5	0,50	0,20	0,30	—	—	4,46	0,0011
8	0,50	0,20	—	—	0,10	5,38	0,0014
11	0,50	0,20	0,20	0,10	—	2,80	0,0007
13	0,50	0,50	—	0,10	—	3,83	0,0010
14	0,50	0,50	—	—	—	5,35	0,0014
16	0,50	0,50	0,20	—	0,10	15,95	0,0041
17	0,50	0,50	0,30	—	—	13,00	0,033
18	0,50	0,50	0,20	0,10	—	4,54	0,0012

Key: (a). Alloy number. (b). Content of alloying elements (according to charge), wt.%. (c). Increase in weight during this time, g/m^2. (d). Rate of corrosion during this time, $g/m^2 \cdot h$.

FOOTNOTE [1]. Time of testing - 265 hours. ENDFOOTNOTE.

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Table 4.

Corrosion resistance of the tempered alloys in water at 350°.

(a) Номер сплава	(b) Содержание легирующих элементов (по шихте), вес. %					(c) Привес за 1500 час., $г/м^2$	(d) Скорость коррозии за 1500 час., $г/м^2 \cdot час$
	Nb	Mo	Sn	Cr	Si		
1	0,80	0,20	0,20	—	—	1,01	0,0006
2	0,80	0,20	—	0,10	—	0,98	0,0006
3	0,80	0,20	—	—	—	1,49	0,0010
4	0,80	0,20	—	—	0,10	2,54	0,0017
5	0,50	0,20	0,30	—	—	0,99	0,0006
6	0,50	0,20	—	0,10	—	0,00	0,0000
7	0,50	0,20	—	—	—	1,09	0,0007
8	0,50	0,20	—	—	0,10	—2,03	—0,0013
9	0,50	0,20	0,20	—	0,10	1,42	0,0009
10	0,50	0,20	0,20	—	—	2,65	0,0017
11	0,50	0,20	0,20	0,10	—	2,57	0,0017
12	0,50	0,50	0,20	—	—	2,83	0,0019
13	0,50	0,50	—	0,10	—	4,81	0,0032
14	0,50	0,50	—	—	—	3,44	0,0022
15	0,50	0,50	—	—	0,10	6,21	0,0041
16	0,50	0,50	0,20	—	0,10	5,07	0,0033
17	0,50	0,50	0,30	—	—	1,12	0,0007
18	0,50	0,50	0,20	0,10	—	1,67	0,0011

Key: (a). Alloy number. (b). Content of alloying elements (according to charge), wt.%. (c). Increase in weight in 1500 hours, g/m^2. (d). Rate of corrosion in 1500 hours, $g/m^2 \cdot h$.

Table 5.

Corrosion resistance of poured alloys in water vapor at 400°.

(a) Номер сплава	(b) Содержание легирующих элементов (по шихте), вес. %					(c) Привес за 1870 час., г/м²	(d) Скорость коррозии за 1870 час., г/м²·час
	Nb	Mo	Sn	Cr	Si		
1	0,80	0,20	0,20	—	—	4,93	0,0026
2	0,80	0,20	—	0,10	—	18,52	0,0099
3	0,80	0,20	—	—	—	8,78	0,0046
4	0,80	0,20	—	—	0,10	19,77	0,0105
5	0,50	0,20	0,30	—	—	17,75	0,0094
6	0,50	0,20	—	0,10	—	2,73	0,0014
7	0,50	0,50	—	—	—	15,34	0,0082
8	0,50	0,20	—	—	0,10	25,48	0,0136
9	0,50	0,20	0,20	—	0,10	37,01	0,0197
10	0,50	0,20	0,20	—	—	23,80	0,0127
11	0,50	0,20	0,20	0,10	—	8,10	0,0043
12	0,50	0,50	0,20	—	—	16,98	0,0090
13	0,50	0,50	—	0,10	—	13,56	0,0072
14	0,50	0,50	—	—	—	30,00	0,0160
15	0,50	0,50	—	—	0,10	33,90	0,0181
16	0,50	0,50	0,20	—	0,10	41,59	0,0222
17	0,50	0,50	0,30	—	—	21,08	0,0112
18	0,50	0,50	0,20	0,10	—	—4,32	—0,0023

Key: (a). Alloy number. (b). Content of alloying elements (according to charge), wt.%. (c). Increase in weight in 1870 hours, g/m². (d). Rate of corrosion in 1870 hours, g/m²·h.

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Since only the results of the last time of testing are given in the tables, the numbers of the increase in weight for 1 m² and the rates of corrosion do not always correctly characterize the corrosion resistance of the alloy, thus, for instance, poured alloy 1 (0.80% Nb+0.20% Mo+0.20% Sn) has a low rate of corrosion due to the incipient peeling of oxide film. By estimating the effect of additives on the corrosion properties of poured alloys in water at 400° and 250 atm, it is possible to say that in all cases, the introduction of tin and

especially silicon leads to a decrease in the rate of corrosion. Additions of chromium, to alloys which contain 0.50% Nb+0.50% Mo and 0.50% Nb+0.20% Mo, have a favorable effect. Of the alloys with 0.80% Nb+0.20% Mo, the best corrosion resistance is characterized by the ternary alloy. After 1870 hours of testing, the oxide film on all alloys not containing silicon, is a dense, bluish-black/ferrous color. The film turns white in the alloys with silicon and it begins to peel. The corrosion resistance of forged alloys is less than in the same alloys in the poured state.

Mechanical tensile tests of the alloys were conducted in an RM-500 machine with a load of 500 kgf at a temperature of 400° in an atmosphere of argon and at room temperature in air. The forged samples were subjected to testing at 400° and those tempered after forging for 20 min at 650°. Only the tempered samples were tested at room temperature. Alloy testing for creep was conducted at temperatures of 400, 500 and 600° in an atmosphere of argon on a TsKTI-750 machine with a stress of 10 kg/mm². The results of testing all the mechanical properties mentioned, are given in Table 7.

It follows from an examination of Table 7 that the alloying of the alloys with chromium leads to an increase in ultimate strength at room temperature. Among the strongest alloys with $\sigma_b = 66{,}99$ and 72.78 kg/mm² are alloys 13 (0.50% Nb+0.50% Mo+0.10 Cr) and 18 (0.50% Nb+0.50% Mo+0.20%Sn+10% Cr). Additions of 0.20-0.30% tin and 0.10% chromium increase the limit of strength of the forged alloys at 400°.

The effect of additions of tin, chromium and especially silicon on alloys in the tempered state is difficult to estimate, since, apparently, the composition of the alloy strongly affects the processes, which occur in the alloys during tempering for 20 min at 650°. Among the strongest alloys at 400° are alloys 6 (0.50% Nb+0.20% Mo+0.10% Cr), 13 (0.50% Nb+0.50% Mo+0.10% Cr, 12 (0.50% Nb+0.50% Mo+0.20% Sn), 10 (0.50% Nb+0.20% Mo+0.20% Sn), 14 (0.50% Nb+0.50% Mo) and 18 (0.50% Nb+0.50% Mo+0.20% Sn+0.10% Cr), for which σ_b lies within the limits of 35.23-42.17 kg/mm². The results of the creep tests make it possible to select two alloys with a high resistivity to creep at 400 and 500°: alloy 5 (0.50% Nb+0.20% Mo+0.30% Sn) and 6 (0.50% Nb+0.20% Mo+0.10% Cr). For them, the creep rates at 400° are 0.010-0.016% for 100 hours, and at 500°-0.084 and 0.077% in 100 hours.

Table 6.

Corrosion resistance of forged alloys in water vapor at 400°.

(a) Номер сплава	(b) Содержание легирующих элементов (по шихте), вес. %					(c) Привес за 1870 час., $г/м^2$	(d) Скорость коррозии за 1870 час., $г/м^2 \cdot час$
	Nb	Mo	Sn	Cr	Si		
4	0,80	0,20	—	—	0,10	14,00	0,0074
5	0,50	0,20	0,30	—	—	9,44	0,0050
8	0,50	0,20	—	—	0,10	20,00	0,0106
11	0,50	0,20	0,20	0,10	—	10,40	0,0055
13	0,50	0,50	—	0,10	—	18,57	0,0099
14	0,50	0,50	—	—	—	42,63	0,0228
16	0,50	0,50	0,20	—	0,10	48,12	0,0257
17	0,50	0,50	0,30	—	—	72,50	0,0387
18	0,50	0,50	0,20	0,10	—	36,67	0,0196

Key: (a). Alloy number. (b). Content of alloying elements (according to charge), wt.%. (c). Increase in weight for 1870 hours, g/m^2. (d). Rate of corrosion for 1870 hours, $g/m^2 \cdot h$.

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Table 7.

Mechanical properties of alloys.

(a) Номер сплава	(b) Содержание легирующих элементов, вес. % (по шихте)			(c) Разрыв при комнатной температуре (кованые и отпущенные)		(d) Разрыв при 400°				(e) Скорость ползучести (в %) за 100 час. при напряжении 10 кГ/мм²		
						(f) Кованые		(g) Кованые и отпущенные				
	Sn	Cr	Si	σ_b, (h) кГ/мм²	δ, %	σ_b, кГ/мм² (h)	δ, %	σ_b, кГ/мм² (h)	δ, %	400°	500°	[illegible]
					(i) Сплав с 0,80% (вес.) Nb и 0,20% (вес.) Mo							
1	0,20	—	—	50,00	16,34	42,31	14,79	27,04	14,03	0,020	0,20	(j) Обрыв через 4 часа
2	—	0,10	—	49,77	12,55	44,88	15,15	27,22	6,83	0,020	0,26	(j) Обрыв через 3 часа
3	—	—	—	46,01	8,65	37,08	11,71	30,44	12,83	0,062	0,155	(j) Обрыв через 1 час
4	—	—	0,10	48,59	10,87	31,70	14,15	30,27	13,04	0,015	0,206	То же (k)
					Сплав с 0,50% (вес.) Nb и 0,20% (вес.) Mo							
5	0,30	—	—	47,10	15,21	38,70	12,55	29,86	12,08	0,010	0,084	То же (k)
6	—	0,10	—	57,38	10,16	43,3[illegible]	10,84	35,23	11,81	0,016	0,077	(l) » »
7	—	—	—	51,74	10,32	34,42	13,48	29,34	15,87	0,045	0,13	(j) Обрыв через 2 часа
8	—	—	0,10	49,72	8,65	48,52	11,67	24,18	12,24	0,026	0,16	То же (k)
9	0,20	—	0,10	54,44	8,00	35,85	13,42	31,15	12,76	0,016	0,30	(j) Обрыв через 1 час
10	0,20	—	—	55,03	5,48	38,46	14,54	37,32	7,44	0,003	0,42	То же (k)
11	0,20	0,10	0,10	45,27	14,89	36,19	13,95	28,70	11,34	0,160	0,32	(j) Обрыв через 5 час.
					Сплав с 0,50% (вес.) Nb и 0,50% (вес.) Mo							
12	0,20	—	—	61,87	12,55	51,26	12,79	36,55	12,06	0,062	0,168	(j) Обрыв через 2 часа
13	—	0,10	—	66,99	8,05	49,02	15,81	36,35	12,06	0,042	0,049	(j) Обрыв через 10 час.
14	—	—	—	60,77	12,08	47,84	9,87	37,36	13,33	0,032	0,237	То же (k)
15	—	—	0,10	58,88	11,73	51,46	11,11	30,20	10,86	0,020	0,061	(j) Обрыв через 8 час.
16	0,20	—	0,10	54,44	9,70	56,48	9,67	31,30	12,03			
17	0,30	—	—	54,58	11,48	49,81	11,21	27,75	18,53			
18	0,20	0,10	—	72,78	10,30	50,79	11,60	42,17	12,88	0,022	0,16	(j) Обрыв через 10 час.
	—	—	—	26,46	9,51	18 48	13,02	9,16	17,90	1,600	—	(m) Обрыв при 400°

Key: (a). Alloy number. (b). Content of the alloying elements, weight, % (according to charge). (c). Rupture at room temperature (forged and tempered). (d). Rupture at 400°. (e). Creep rate (in %) for 100 hours with a stress of 10 kg/mm². (f). Forged. (g). Forged and tempered. (h). kg/mm². (i). Alloy with ... (weight) Nb and ... (weight) Mo. (j). Break in ... hours. (k). The same. (l). Break in ... hour. (m). Break at ....

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CONCLUSIONS.

1. Alloying of ternary alloys Zr+0.80-50% Nb+0.20-0.5% Mo 01% chromium, 0.1% silicon and especially 0.2-0.3% tin, impairs their heat resistance in air at 650° (20 hours).

2. Alloying of the ternary alloy Zr+0.80% Nb+0.20% Mo with 0.2% tin, 0.1% chromium and 0.1% silicon, impairs its corrosion resistance in water at 350° and 168 atm (in a poured state); additions of 0.2-0.3% tin and 0.1% silicon to alloys of Zr+0.50% Nb+0.20% Mo and Zr+0.50% Nb+0.50% Mo, cause a decrease, and additions of 0.1% chromium - an increase in corrosion resistance in water at the indicated parameters. Alloying with chromium also leads to an improvement in the corrosion properties of forged alloys.

3. Alloying of alloys of Zr+0.50% Nb+0.20% Mo and Zr+0.50% Nb+0.50% Mo with 0.1% chromium, increases their corrosion resistance

in water vapor at 400° and 250 atm, additions of 0.2-0.3% tin and 0.1% silicon lead to a reduction in corrosion resistance of all alloys under the indicated conditions.

4. Mechanical tensile tests at room temperature and 400°, and also the creep test at 400, 500 and 600°, showed that the strongest and most creep-resistant alloys can be obtained on the basis of the ternary alloys Zr-0.50% Nb+0.50% Mo and Zr+0.50% Nb+0.20% Mo via alloying them with chromium (0.1%) and tin (0.2%).

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